Clean Copy

NOZZLE EXIT CLOSURE SYSTEM SEPARABLE BY ELECTRICALLY INITIATED PYRO SYSTEM

FIELD OF INVENTION

The present invention relates to a nozzle exit closure system, separable on command, which provides thermal protection and prevent hot gas entry into the nozzle from outside.

BACKGROUND OF INVENTION

In rockets with clustered multiple nozzle configurations, non-firing engines need to be provided with separable nozzle exit closures for thermal protection and to prevent contamination of thrust chamber due to hot gas entry. A launch vehicle, capable of placing 3 ton class satellite in geostationary orbit was configured with solid strap-on (ground lit) and a core liquid engine (air lit). The nozzles of the ground lit solid motors and air lit liquid engines are adjacent to each other. As the vehicle ascends to higher altitude, the plumes of solid motors expand and interact with each other, leading to reverse flow of hot gases. To protect the adjacent non firing, liquid engine nozzles from these hot gases and high thermal radiations, the exits of liquid nozzle need to be protected by nozzle exit closure.

An exhaustive prior art search revealed the existence of the following related to nozzle closures:

US Patent 2645999 describes a closure which comprises a generally cup shaped metallic member having a cylindrical wall and a reentrant bottom of open work form and comprising spiders. The closure is cemented to the nozzle plate over the entire bearing area. The assembly combines the nozzle closure and contact ring, into one unit which is blown off at the time the rocket is fired.

US Patent 3020710 discloses a closure made of suitable thermoplastic material and circular in cross-section. It comprises a skirt portion of frusto-conical configuration which is designed to engage the nozzle wall and which terminates.

at one of its ends in a transverse closure wall. The wall provides the flexural means and the controlled bursting strength. The closure is bonded to the nozzle wall by plastic bonding

material. At a predetermined gas pressure, transverse wall of closure will be fractured and comparatively small portion thereof is blown out. Remaining portions of the closure, including the skirt portion is peeled back by the hot gases and is burned off the nozzle wall release of pressure there from. The closure includes a forward portion extending into the motor and an aft end portion extending rearwardly into the exit portion of the nozzle. The mass and geometry of both the forward and aft sections are predetermined to control the pressure release by the rate of change of momentum of the closure during motor ignition.

US Patent 330865 describes a closure member which is capable of receiving a flexible diaphragm and snap ring which expand the closure member into engagement with the nozzle. The closure member is thus retained and sealed to the nozzle. At predetermined pressure the diaphragm will fill and the entire closure assembly is exhausted from the nozzle with the exhaust gases.

US Patent 3910191 discloses a nozzle closure which includes an expansion seal having a peripheral edge which is radially expandable outward by interaction with a plug shaped expander. Both the seal and the expander are provided with openings to allow passage of a connecting bolt. For assembly, a nut is torqued into position so that the expander causes expansion of seal and thus controls the deformation of edge as it engages the nozzle throat. The force that the seal exerts on the throat controls the gas pressure required to blow the seal out of the throat during missile firing.

US Patent 3228334 describes a system formed with a substantially cylindrical portion and a rim portion which is press fitted into the nozzle. This unit is slightly enlarged throughout the cylindrical portion to ensure press fit relationship with the interior nozzle, and the tight fit provides ejection at predetermined pressure. The rim portion of the-unit, which fits the flared portion of the nozzle is formed with partial radial cuts to divide the rim portion into a plurality of segments. The forward side of the plug is covered with a plate which reinforces the plug. This plate is bonded to the exposed side of the plug with cement and grooved to control the blow out pressure. At predetermined pressure the plate will fail and the entire closure assembly is exhausted from the nozzle with the exhaust gases.

Mostly nozzle closures are used for solid motors where it is bonded or assembled to the nozzle throat or divergent. When the pressure inside the chamber reaches a predetermined

level, these nozzle closures are blown off from the nozzle (passive systems).

Therefore, there is a need to provide a nozzle exit closure, which is separable on command and is designed in such a way that, it can be separated remotely by a command at a specific time even without internal pressure.

OBJECTS OF INVENTION

It is an object of the present invention to provide a-nozzle exit closure for non-firing engine nozzles, which will provide thermal protection and prevent hot gases entry into the nozzle from outside.

Another object of the present invention is to design a nozzle exit closure which can be separated on command.

Still another object of the present invention is to develop a mechanism which can provide structural support to thermal protection system.

Yet another object of the present invention is to develop a nozzle exit closure system which shall provide functional status upon command for separation.

Still yet another object of the present invention is to develop a system which shall not create any debris during functioning which may disturb the ongoing vehicle.

SUMMARY OF THE INVENTION

In an aspect of the present invention, there is provided a nozzle exit closure system which is separable on command and prevents hot gas entry into the nozzle from outside. In this system, nozzle exit closure is attached to a ring welded on to the nozzle divergent through sixteen spring loaded latches using a steel wire rope. Torsion springs are provided at hinges of all latches. The wire rope is pre tensioned by turnbuckle arrangement to counter the torsion spring as well as to withstand the flight loads. For separation of nozzle exit closure, wire rope is cut by pyro rope cutters. This leads to the opening of sixteen spring-loaded latches and results in the release of closure from the on-going vehicle. This nozzle exit closure system can also withstand the differential pressure with positive pressure inside the nozzle compartment during ascent and can withstand the high vibration levels during flight. This is an essential subsystem for a heavy lift launcher intended to launch 3 to 5_ton class of satellites to geostationary orbit with air lit liquid core engine and ground lit solid booster.

Further scope and applicability of the present invention will become apparent from the detailed description given hereafter.

BRIEF DESCRIPTION OF DRAWINGS

The invention will now be described in detail with reference to the embodiments shown diagrammatically in drawings wherein1- circular frame assembly, 2- nozzle divergent, 3-ring, 4- spokes, 5- latches, 6- wire rope, 7- wire rope cutter, 8- composite thermal blanket, 9-load cell.

Figure 1 illustrates the schematic of nozzle exit closure (100)

Figure 2 illustrates Schematic of Nozzle Closure Structure

Figure 3 illustrates Schematic of attachment with spring loaded latch

Figure 4 illustrates Schematic of turnbuckle assembly

Figure 5 illustrates Schematic of separation connector for functional status monitoring

DETAILED DESCRIPTION OF THE INVENTION

For the purposes of the following detailed description, it is to be understood that the invention may assume various alternative variations and step sequences, except where expressly specified to the contrary. Moreover, other than in any operating examples, or where otherwise indicated, all numbers expressing, for example, quantities of ingredients used in the specification are to be understood as being modified in all instances by the term "about". It is noted that, unless otherwise stated, all percentages given in this specification and appended claims refer to percentages by weight of the total composition.

Thus, before describing the present invention in detail, it is to be understood that this invention is not limited to particularly exemplified systems or process parameters that may of course, vary. It is also to be understood that the terminology used herein is for the

purpose of describing particular embodiments of the invention only, and is not intended to limit the scope of the invention in any manner.

The use of examples anywhere in this specification including examples of any terms discussed herein is illustrative only, and in no way limits the scope and meaning of the invention or of any exemplified term. Likewise, the invention is not limited to various embodiments given in this specification.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention pertains. In the case of conflict, the present document, including definitions will control.

It must be noted that, as used in this specification and the appended claims, the singular forms “a,” “an” and “the” include plural referents unless the content clearly dictates otherwise. Thus, for example, reference to a “polymer” may include two or more such polymers.

The terms “preferred” and “preferably” refer to embodiments of the invention that may afford certain benefits, under certain circumstances. However, other embodiments may also be preferred, under the same or other circumstances. Furthermore, the recitation of one or more preferred embodiments does not imply that other embodiments are not useful, and is not intended to exclude other embodiments from the scope of the invention.

In an aspect of the present invention, there is provided a nozzle exit closure system (100) for rockets comprising:

a circular frame assembly (1) having plurality of spokes (4) configuration; at least eight spoke;

a nozzle divergent (2) with a ring (3) a welded thereon; said nozzle divergent ring (3) is connected to said circular frame assembly (1) through a plurality of spring (11) loaded latches (5);

characterized in that plurality of latches (5) connected by a steel wire rope (6) pre-tensioned

by turnbuckle arrangement (400) and is released by cutting the wire rope (7) using a pyro wire rope cutter.

In an embodiment of the present invention, the wire rope (6) is pre-tensioned by turnbuckle arrangement (400).

In an embodiment of the present invention, the closure consists of a composite thermal blanket (8) made of multiple layers of silica fabric, heatlab and nitrile rubber sheet supported by said metallic frame.

In an embodiment of the present invention, the loop with rope (6) passing over the spring loaded latches (5) is placed in the groove of nozzle divergent (2).

In an embodiment of the present invention, a load cell (9) is located near the turnbuckle (400) for monitoring the tension of the wire rope (6).

In an embodiment of the present invention, the closure comprises two wire rope cutters (7) provided side by side for redundancy in function.

In an embodiment of the present invention, the hinge arrangement (10) is provided for latches (5) for adjusting to local deformation of nozzle.

In an embodiment of the present invention, the nozzle exist closure is released by cutting the wire rope using a pyro wire rope cutter.

In an embodiment of the present invention, the venting is provided on latches (5) for limiting the differential pressure.

The nozzle exit closure of the present invention is separable on command, provide thermal protection and prevent the hot gas entry into the nozzle from outside.

The circular metallic framework (1) is attached to the ring (3) welded on said nozzle divergent (2) through a wire rope (6) of sixteen spring loaded latches (5).

Nozzle closure system (100) of the present system is described using Figure 1, which consists of a composite thermal blanket (8) made of multiple layers of silica fabric, heatlab and nitrile rubber sheet supported by a metallic frame work (1). The metallic framework (1) as shown in Figure 2 is made of eight spoke (4) configurations. Each spoke is made of curved C-channel. The system is attached to a ring (3) welded on to the nozzle divergent (2) (Nozzle end ring) through sixteen spring loaded latches (5). The nozzle end ring (3) is configured with a groove and a matching profile is provided for latches for proper seating. Further, electrical wires are routed to the Nozzle exit closure through a metallic conduit (made of Stainless steel) (27), provided outside the nozzle as shown in figure 1. This is for protecting the electrical wires from aerodynamic heating.

The closure is attached to the nozzle end ring (3) using a wire rope (6) as shown in Figure 3. End of the thermal blanket (8) is looped inside the groove around the metallic wire rope (6) for drawing the wire rope (6). Spring loaded latches (5) are provided at sixteen locations between the metallic frame (1) and nozzle end ring (2). The loop with rope (6) passing over the spring loaded latches (5) is placed in the groove of nozzle end ring (2) as shown in Figure 3. Torsion springs (11) are provided at hinges (10) of all latches (5). The wire rope (6) is pre-tensioned to counter the torsion spring as well as to withstand the flight loads. As shown in Figure 4, a turnbuckle (400) is provided on the wire rope (6), for pre-tensioning to the required value. A load cell (9) located near the turnbuckle monitors the tension of the wire rope (6).

At the time of separation of nozzle closure system, wire rope (6) is cut by pyro rope cutters. This leads to the opening of sixteen spring loaded latches (5) and results in the release of closure from the ongoing vehicle.

<u>Stepwise working of Nozzle exit closure system</u>

Once the command is issued to the wire rope cutter, the wire rope (6) will be cut and the tension in the wire rope (6) becomes zero. Wire rope cutter is a pyrotechnic device which has a hole for passage of wire rope (6) through it. Once command is issued for cutting the rope, a charge in the device is ignited, which would result in the movement of a chisel for cutting the wire rope (6) passing through the device. Once the tension in the wire rope (6) is lost, all the latches opens out radially by 90deg. under the action of torsion springs. This causes the

latches to come out of the groove of the Nozzle end ring (3). Once the latches come out of the Nozzle end ring (3), the exit closure is released from the Nozzle.

Working of Latch Mechanism

Sixteen latches (5) are provided for attaching the exit closure to Nozzle end ring (3). Each latch individually has a degree of freedom for rotation about the hinge pin. Each latch is provided with a torsion spring also. Hinge pins are structurally connected to exit closure. The latches are rotated about the hinge pin, against the torsion springs, so that the curved portion of the latches get seated in the groove provided in Nozzle end ring (3). In this condition, the metallic wire rope (6) inside the groove is tensioned and this prevents latches from opening radially [Figure 3]. Once the wire rope (6) is tensioned to the required value, the system acts as a structure. For releasing the system, the tension in the wire rope is brought to zero by cutting the wire rope (6).

Working of Turnbuckle

Turnbuckle arrangement (400) is provided for tensioning of the wire rope (6) to the specified value. The ends of the wire rope (6) is looped and connected to the two forks (12,13) of turnbuckle (400) (Figure 4). These forks (12, 13) are in turn connected to two sliding blocks (14, 15). These blocks (14, 15) are interconnected and held in place by a long screw (16). When the screw (16) is tightened by rotating a nut (17) and holding the head (18), the sliding blocks (14, 15) are brought closer and closer, which in turn increases the tension in the wire rope (6). A load cell (9) is kept between the head (18) of the screw and the sliding block (14). The load cell (9) is compressed when the wire rope (6) is tensioned. The load cell (9) is a hollow cylindrical component with strain gauges bonded on its outside surface. The compressive load will produce strain in the strain gauges which is used to monitor tension in the wire rope (6). The wire rope (6) used in the system is a flexible metallic wire rope of 7x19 construction.

Working of connector components

The Nozzle exit closure system (100) of the present invention has three electrical connectors (21, 22, 23). Out of that, two are non separating connectors (21, 22) and one is a separating

connector (23). Non separating connectors (21, 22) are devices which are manufactured as two parts, and once assembled, they provide electrical continuity and act as a single device (Figure 5). These connectors (21, 22) will be intact throughout the functioning of the system and electrical continuity is not disturbed. Separating connector (23) is also manufactured as two parts and once assembled, they provide electrical continuity. Whereas during the functioning of the system, if a specified force is applied to one part, the parts will get physically separated and electrical continuity will be broken (Figure 5). Usually, a lanyard (24) is provided on one part of such connectors (23) to facilitate application of force. Such connectors (23) are provided in separation systems for routing of electrical lines between the separating parts and monitoring separation status.

Separating connector (23) is capable of separating into two parts if the lanyard (24) is pulled with a specified force. In the Nozzle exit closure, one half of separating connector (23) (non lanyard part) is attached to Nozzle end ring (3) and the lanyard part (24) is attached to the separable exit closure with certain slackness. Once the exit closure is released and when it moves physically away, it exerts force on the lanyard (24) and the connector (23) is separated into two parts, which gives a discontinuity in the electrical circuit, indicating the physical separation.

In an embodiment of the present invention, two wire rope cutters are provided for redundancy.

The system can maintain integrity even if nozzle deflects locally. All the latches (5) have freedom to rotate about the hinge axes and thus, can adjust to the local deflections on nozzle.

The physical separation of system (functional status monitoring) is confirmed by de-mating of the lanyard (24) based electrical separation connector (23) as shown in Figure 5.

The present invention of nozzle exit closure separable on electric command has the following applications:

1. The Nozzle exit closure system (100) of the present invention can be used as an active separation of nozzle exit closure in launch vehicles, missiles and aircrafts.
2. The Nozzle exit closure system (100) of the present invention can be used as remotely

operated safety cover for any openings in industrial equipment.

Also the present invention provides the functional status of separation of exit closure which was not described in any of the prior arts. The present invention does not create any debris during functioning, whereas the systems discussed above create debris on the nozzle during functioning. Systems based on prior inventions do not provide any venting provision for limiting the differential pressure whereas the current invention provides venting provision for limiting the differential pressure. The present system can maintain integrity even if nozzle deflects locally, whereas the systems described in the prior art do not have this capability.

It is thus clear that the prior known nozzle closures suffer from several drawbacks and these drawbacks of the prior art evolved the need for the development of a nozzle exit closure separable on command which overcomes many of the shortfalls of the above cited systems.

One skilled in the art may develop equivalent compositions, materials, and methods without the exercise of inventive capacity and without departing from the scope of the invention. It will be understood that many variations can be made in the procedures herein described while still remaining within the bounds of the invention. It is the intention of the inventors that such variations are included within the scope of the invention.

Clean Copy

We claim:

1. A nozzle exit closure system (100) for rockets comprising:

a circular frame assembly (1) having plurality of spokes (4) configuration; at least eight spoke;

a nozzle divergent (2) with a ring (3) welded thereon; said nozzle divergent ring (3) is connected to said circular frame assembly (1) through a plurality of spring (11) loaded latches (5);

characterized in that

said plurality of latches (5) are connected by a steel wire rope (6) pre-tensioned by a turnbuckle arrangement (400) and is released by cutting the wire rope using a pyro wire rope cutter .

2. The nozzle exit closure as claimed in claim 1, wherein said wire rope (6) is pre-tensioned by said turnbuckle arrangement (400).
3. The nozzle exit closure as claimed in claim 1, wherein said closure consists of a composite thermal blanket (8) made of multiple layers of silica fabric, heatlab and nitrile rubber sheet supported by said circular frame (1).
4. The nozzle exit closure as claimed in claim 1, wherein said closure includes a loop with rope (6) passing over said spring loaded latches (5) which is placed in a groove of said nozzle divergent (2).
5. The nozzle exit closure as claimed in claim 1, wherein said closure includes a load cell (9) which is located near said turnbuckle (400) for monitoring the tension of said wire rope (6).
6. The nozzle exit closure as claimed in claim 1, wherein said closure comprises two wire rope cutters (7) provided side by side for redundancy in function.
7. The nozzle exit closure as claimed in claim 1, wherein said closure includes a hinge

arrangement (10) which is provided for said latches (5) for adjusting to local deformation of said nozzle.

8. The nozzle exit closure as claimed in claim 1, wherein said nozzle exist closure is released by cutting the wire rope using said pyro wire rope cutter.

9. The nozzle exit closure as claimed in claim 1, wherein said latches (5) are provided with venting for limiting the differential pressure.

Date: 01/03/2019

Sudarshan Kumar Bansal
Advocate & Registered Patent Agent
(Agent for the Applicant)
(IN/PA/353)

CLEAN COPY

Name of the Applicant: **Drawing Sheet 1 of 5**
INDIAN SPACE RESEARCH ORGANISATION

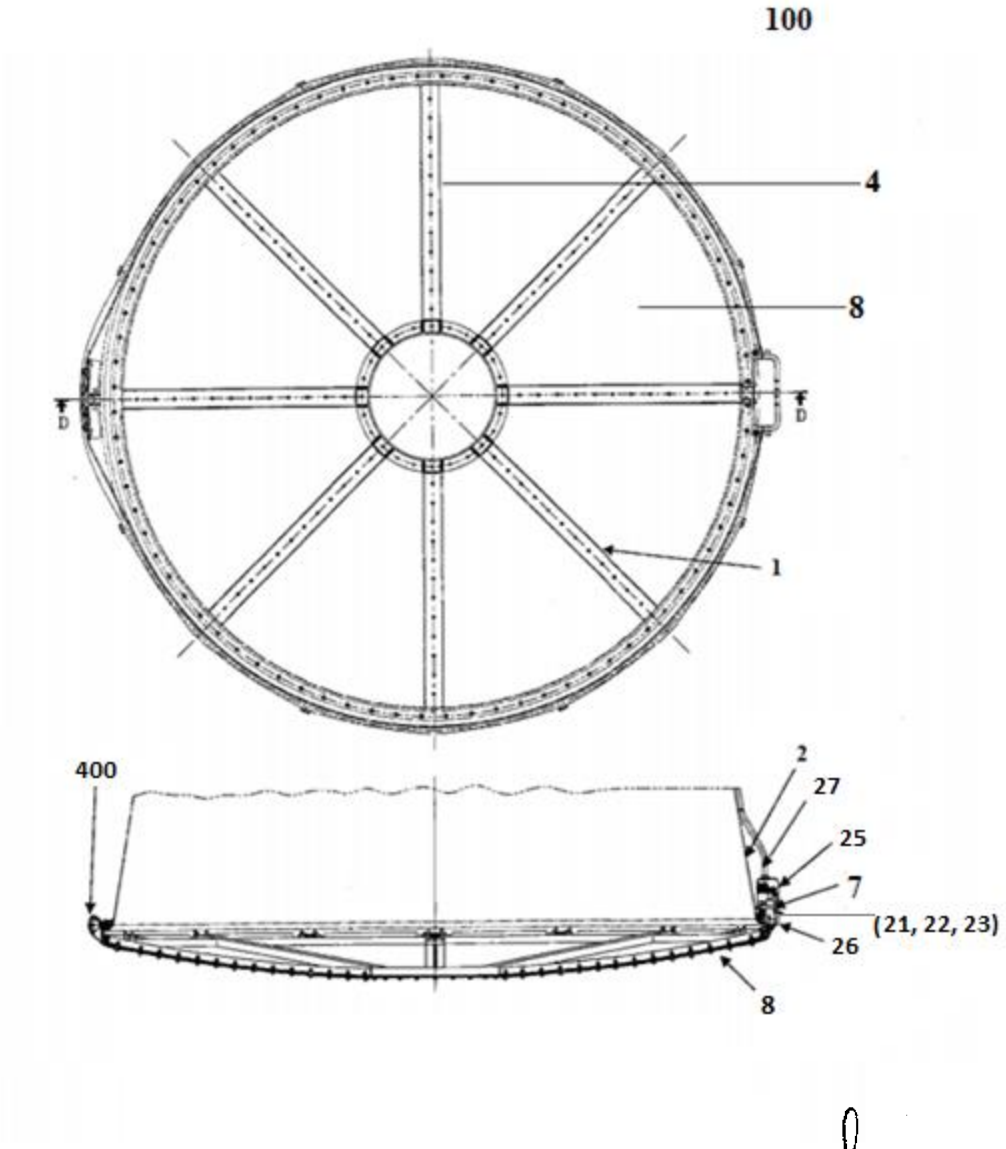

Figure 1

Date: 01/03/2019

Sudarshan Kumar Bansal
Advocate & Registered Patent Agent
(Agent for the Applicant)
(IN/PA/353)

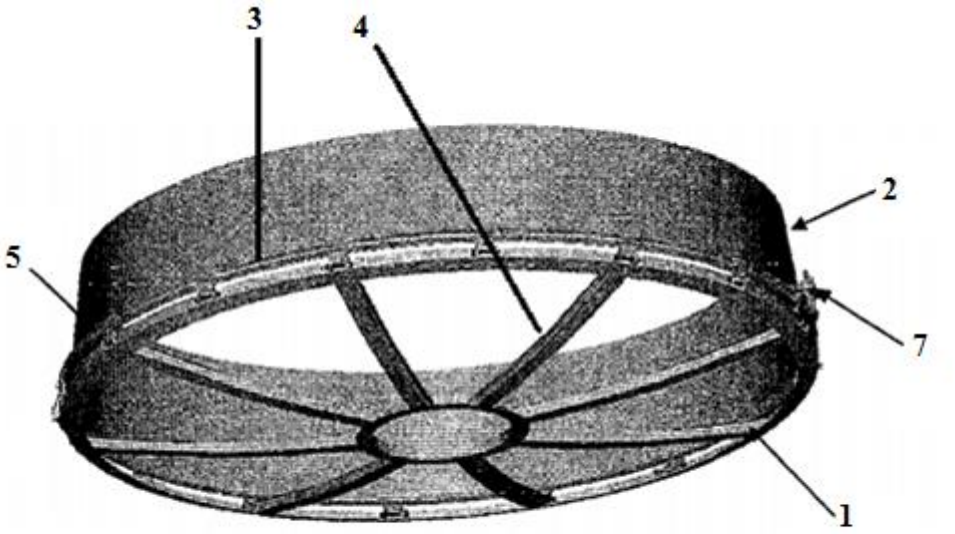

Figure 2

Date: 01/03/2019

Sudarshan Kumar Bansal
Advocate & Registered Patent Agent
(Agent for the Applicant)
(IN/PA/353)

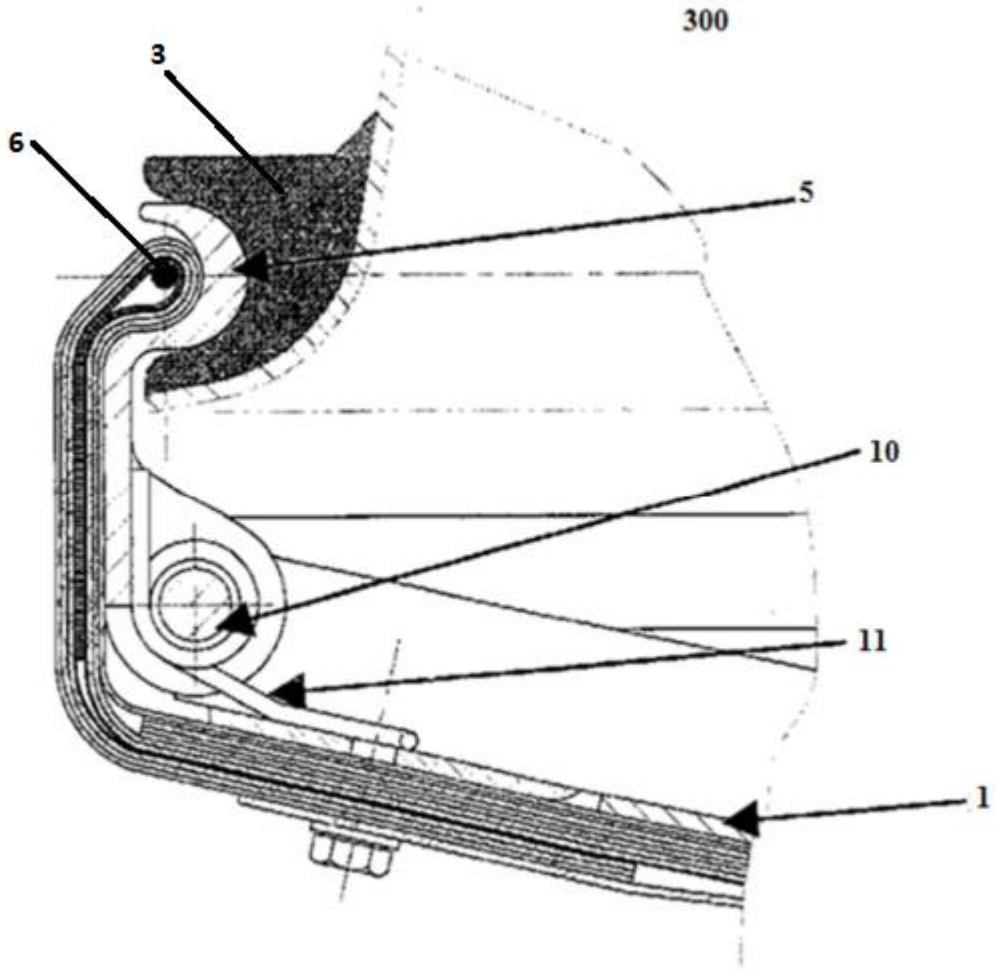

Figure 3

Date: 01/03/2019

Sudarshan Kumar Bansal
Advocate & Registered Patent Agent
(Agent for the Applicant)
(IN/PA/353)

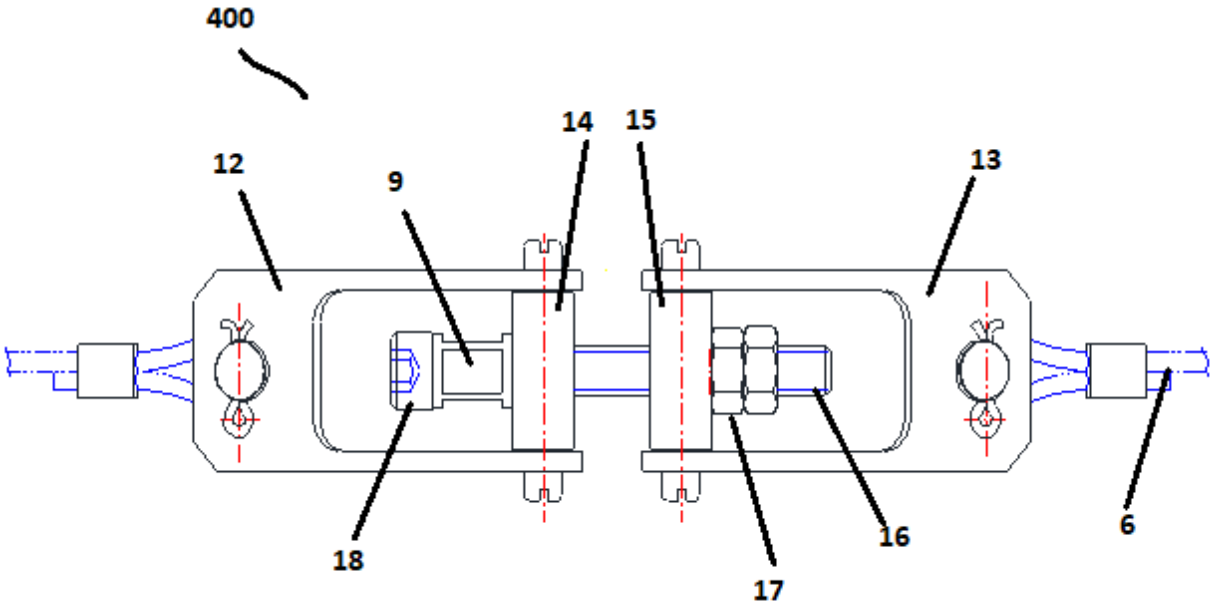

Figure 4

Date: 01/03/2019

Sudarshan Kumar Bansal
Advocate & Registered Patent Agent
(Agent for the Applicant)
(IN/PA/353)

Name of the Applicant: **Drawing Sheet 5 of 5**
INDIAN SPACE RESEARCH ORGANISATION

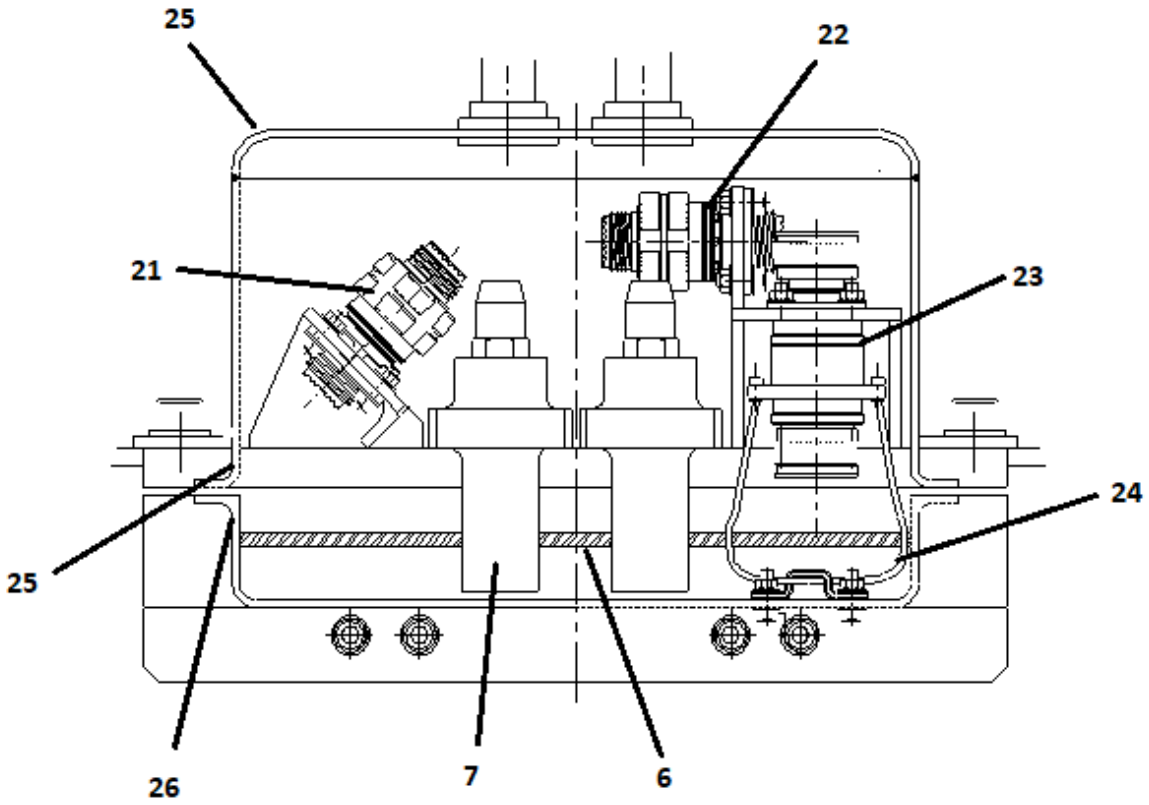

Figure 5

Date: 01/03/2019

Sudarshan Kumar Bansal
Advocate & Registered Patent Agent
(Agent for the Applicant)
(IN/PA/353)